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Indian Standard

NICKEL CADMIUM AIRCRAFT BATTERIES (AEROBATIC AND NON-AEROBATIC) — SPECIFICATION

UDC 621·355·82 : 629·7·064

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

March 1992

Price Group 6

Secondary Cells and Batteries Sectional Committee, ETD 11

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Secondary Cells and Batteries Sectional Committee had been approved by the Electrotechnical Division Council.

The special features of a battery operating in an aircraft, namely light weight, correct overall dimensions and standard terminal arrangements ensuring quick interchangeability, ability to withstand low pressures and low temperatures and other effects of high altitude flying, have all been taken into consideration in evolving the tests and prescribing the limiting values specified in this standard.

Nickel cadmium batteries intended for non-aerobatic as well as aeroatic type of aircraft have been covered in this standard. This standard at present, covers only 24 V and up to 40 Ah batteries.

Lead acid batteries intended for non-aerobatic as well as aerobatic types of aircraft are covered by IS 1846 (*under revision*).

In the preparation of this standard, assistance has been derived from the following:

BS3G 205 : 1983 Specification for lead-acid and nickel-cadmium rechargeable batteries. British Standards Institution.

BS3G 100 Specification for general requirements for equipment for use in aircraft. British Standards Institution.

MIL-B-81755557a : 1979 Batteries and cells, storage, nickel cadmium, aircraft, General Specification for.

MIL-B-26220D : 1974 Batteries, storage, aircraft, nickel cadmium, General Specification for.

General requirements and methods of tests for vented type of nickel cadmium alkaline batteries are covered in IS 10918 : 1984 Specification for vented type nickel cadmium batteries.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

NICKEL CADMIUM AIRCRAFT BATTERIES (AEROBATIC AND NON-AEROBATIC) — SPECIFICATION

1 SCOPE

1.1 This standard covers the requirements of general design, constructional details, etc for vented rechargeable nickel cadmium alkaline batteries for use in either aerobatic or non-aerobatic type of aircraft.

NOTE — At present, the scope of this standard is restricted to batteries of 24 V and up to 40 Ah only. It is intended to include at a later date the requirements of other types of batteries of 12 V and 24 V.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
1885 (Part 8) : 1986	Electrotechnical vocabulary: Part 8 Secondary cells and batteries (*first revision*)
10918 : 1984	Specification for vented type nickel cadmium batteries

3 TERMINOLOGY

3.0 For the purpose of this standard, the definitions included in IS 1885 (Part 8) : 1986 and IS 10918 : 1984 shall apply, together with the following definitions.

3.1 Storage Life of Battery

The period for which a new battery may be stored at the specified temperature without deterioration.

3.2 Discharged Battery

A battery which has been discharged at an ambient temperature of 27 ± 2 °C at the C_1 rate down to a battery voltage corresponding to a mean voltage per cell of 1·00 V for nickel cadmium batteries.

3.3 Battery Runway

A battery condition that is characterised by increasing cell temperature and charging current during constant potential charging and that, if not controlled, can result in the destruction of the battery.

3.4 Manufacturer's Instruction

Those service instructions in the operating and maintenance manual provided by the battery manufacturer and approved by the inspection authority.

3.5 Rated Capacity

Capacity expressed in ampere-hours (Ah) equivalent to 1 C_1 rate.

3.5.1 *1C Rate*

The current specified by the manufacturer that the battery is to deliver for 1 h when it is discharged down to a battery voltage corresponding to a mean voltage per cell of 1·00 V at an ambient temperature of 27 ± 2 °C.

3.6 Serviceable Battery

A battery which conforms physically to the manufacturer's design and which will deliver its rated capacity.

3.7 Normal Servicing

Includes cleaning, charging and electrolyte topping-up, as specified by the manufacturer's instructions, but does not include the replacement of cells.

3.8 Type Tests

Tests carried out to prove conformity with requirements of this specification. These are intended to prove the quality of design, manufacture and workmanship of a given type of battery.

3.9 Acceptance Tests

Tests carried out on samples selected at random from a lot for the purpose of verifying the acceptability of lot.

3.10 Lot

All batteries of the same type, design and rating manufactured by same factory during the same period using the same process and materials offered for inspection at a time shall constitute a lot.

3.11 Routine Tests

Tests carried out on each battery to check the requirements which are likely to vary during production.

4 MATERIALS, CONSTRUCTION AND WORKMANSHIP

4.1 Battery Container and Lid

The requirements of container and lid (whenever provided) shall meet in general the provisions given in **3.1.1** of IS 10918 : 1984. The battery container and lid shall be of stainless steel material. The latches, hooks, vent tubes, etc shall be also of stainless steel material. The battery container and lid shall have smooth sides except for the receptacles, hold-down bar, vent tubes, nameplate, latches and polarity marking. The stainless steel container and lid shall be lined with insulated film or coated from inside to prevent short circuit.

4.2 Cell Containers

Cell containers shall meet the general requirements given in **3.1.2** of IS 10918 : 1984. The cell containers shall be of nylon or any other approved material, impervious and resistant to KOH electrolyte. Tongue-in-groove construction or any other approved design suitable for sealing or welding may be adopted to form a leak resistant joint.

4.3 Cell Lids

The material shall be of polyamide or any other approved material impervious and resistant to KOH electrolyte and shall be thermally welded to the cell container to provide a liquid tight joint. However, if technology of thermal welding is, not available, then adhesive sealing could be accepted subject to the agreement between the supplier and the purchaser.

4.4 Terminals

Size of the battery terminals shall be as per the requirements of cells. These shall be made of solid copper or brass and shall be suitably protected by nickel plating.

4.4.1 *Intercell Connectors*

Intercell connectors shall consist of heavy gauge nickel plated EC grade copper to provide low resistance to minimize voltage drop and temperature build up during engine starting. They shall be adequately nickel plated to prevent corrosive attack.

4.4.2 *Terminal Posts*

The terminal posts of each cell shall be of copper of appropriate size which shall ensure good conductivity and mechanical strength required for the battery. It shall be adequately protected by nickel plating to prevent corrosion by chemical attack.

4.4.3 *Terminal Nut*

Terminal nut shall be made of copper and adequately nickel plated.

4.5 Washers

Wherever rubber washers are employed, they shall be made of synthetic rubber. Spring washers shall be of appropriate spring steel.

4.6 Battery Socket

The battery socket shall be as specified in the individual specification.

4.7 Venting Device

The venting device shall meet in general the requirements given in **3.4** of IS 10918 : 1984.

4.7.1 *Vent Plug*

Vent plug shall be made up of stainless steel or other approval polyamide alkali resistant material.

4.7.2 The vent plugs shall be provided with a one way valve that vents out gas, but prevents electrolyte leakage if the cell or battery is inverted or tilted as the case may be.

4.8 Electrolyte

The electrolyte used shall meet the requirements given in **3.5** of IS 10919 : 1984.

4.9 Separators

The separator used for the cells shall meet in general the requirements given in **3.6** of IS 10918 : 1984.

4.9.1 Non-woven type of separators made of nylon or cellophane shall be used. The separator chosen shall be alkali resistant and dimensionally stable without deformation at the temperature of use.

4.10 Plates

4.10.1 Plates shall be sintered using pure carbonyl nickel powder around nickel wire screen or mesh. Positive plates shall be impregnated with nickel salts and negative plates shall be impregnated with cadmium salts. They shall be sufficiently robust to withstand the normal stress to be expected in service.

4.10.1.1 The individual plate tabs are to be 'combed' to avoid pressure on adjacent plates, which may cause localized hot spots and shorts.

4.10.2 The nickel tabs shall be of proper size suitable for carrying maximum current and shall be electrically welded to each plate.

4.11 Protection

All the surfaces will be suitably painted with alkali proof epoxy paint. In case of stainless steel boxes, the surface will be clean and painted to provide a non-reflecting surface.

4.12 General

4.12.1 *Battery*

Battery shall consist of requisite number of cells assembled together.

4.12.2 *Sealing Cement*

Cell lids shall preferably be thermally welded to the cell containers to provide liquid tight joint. However, sealing cement, if used for the above purpose shall adhere thoroughly to the parts coming in contact with it. The joints shall not crack or become deformed within a temperature range of minus 40°C to plus 70°C. The cementing material shall have no chemical action with the electrolyte. The cement shall not loosen or crack when the battery is subjected to vibration tests.

4.12.3 *Terminal Arrangements*

The final positive and negative connections from the complete battery assembly shall be brought out to an insulating terminal block mounted on one side of the outer metal case. Both the terminals shall be located on the same and face of the battery, the positive terminal being at the right-hand side when viewed from the terminal end of the battery.

4.12.3.1 The terminals and the intercell connectors shall be so designed that they are capable of withstanding the short circuit tests as specified in **9.7.19**. There shall not be any damage or over heating of the terminals/ intercell connectors.

4.12.3.2 It shall be impossible for the positive cable connector to be secured to the negative terminal of the battery, and vice versa.

4.12.3.3 The terminals shall be adequately guarded against the possibility of accidental short circuits.

4.12.3.4 Means shall be provided for eliminating all risks of the connection slakening due to vibration or movement of the cable.

4.12.3.5 A positive symbol on cell or cell block shall be provided in the form of a raised or indented polarity symbol and a suitable red identification. The negative terminal need not be identified.

4.12.3.6 No live portion of the connector shall protrude either when connected to or disconnected from the battery, and the connector shall be so designed that dummy storage is not required.

4.12.4 *Hold-Down Fitments*

Where the battery can be lifted by the connector, vent tubes or other natural hand holds, these shall be so designed that they can carry the load without derangement.

4.12.5 The carrying handles provided in the battery shall be so arranged that when the battery is carried in the appropriate manner the electrolyte shall not spill and the battery cannot be accidentally detached from its handle.

5 CELL DESIGNATION

5.1 The cells shall be designated in accordance with **4** of IS 10918 : 1984.

6 DESIGN REQUIREMENTS

6.1 The batteries shall meet the design requirements pre-receipt inspection of stores/consignment, warranty clause, literatures/document and tool kit is given in Annex A.

7 MARKING AND PACKAGING

7.1 Each battery shall be marked indelibly with the following particulars:

a) Reference to this standard IS.......,
b) Description of the battery including nominal voltage and rated ampere-hour capacity,
c) Manufacturer's code,
d) Month and year of manufacturer,
e) Battery serial number,
f) Contact/supply order number, and
g) Charging and other special instructions.

7.2 Packaging

7.2.1 The battery shall be suitably packed to withstand transit hazards. The battery may be packed in cardboard box or wooden case. While packing, precautions must be taken to keep batteries upright position. The packing case shall be legibly marked to read—THIS SIDE UP, TOP, BOTTOM.

7.2.2 In addition to above, the packaging shall be in accordance with the terms of contract.

8 WORKMANSHIP AND FINISH

8.1 The battery and its components shall be manufactured and processed in careful workmanship like manner in accordance with the design and sound engineering practice and to the entire satisfaction of the inspection authority.

9 TESTS AND REQUIREMENTS

9.1 Categories of Tests

The batteries shall be calculated/tested at various stages under following categories of tests:

a) Type tests,
b) Acceptance tests, and
c) Routine tests.

9.2 Type Tests

The tests specified in Table 1 shall be carried out as type tests. Qty 8 Nos of samples shall be submitted by the manufacturer for carrying out the tests. The distribution of samples is shown in Table 1, additional samples required for user trials will be indicated in the individual specification.

Table 1 Type Tests and Distribution of Samples

(*Clause* 9.2)

Type approval Tests in order of Application

Sl No.	Test Details	Clause Reference	Test Group I	II	III	IV	V	VI	VII
			Number of Batteries						
			1	1	1	2	1	2	X
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.	Physical examination	9.7.1	×	×	×	×	×	×	×
2.	Dimensions and weight	9.7.2	×	×	×	×	×	×	×
3.	Markings	9.7.3	×	×	×	×	×	×	×
4.	Polarity of plates	9.7.4	×	×	×	×	×	×	×
5.	Efficiency of sealing	9.7.5	×	×	×	×	×	×	×
6.	Di-electric test	9.7.6	×	×	×	×	×	×	×
7.	Nominal capacity at 1 h rate	9.7.7	×	×	×	×	×	×	×
8.	Un-spillability	9.7.8	×	×	×	×	×	×	×
9.	Insulation resistance	9.7.9	×	×	×	×	×	×	×
10.	Internal resistance	9.7.10	×	—	—				
11.	Charge retention	9.7.11	×	—	—				
12.	High rate discharge at normal temperature	9.7.12		×	—				×
13.	High rate discharge at low temperature	9.7.13			×				—
14.	Low temperature performance	9.7.14	×						
15.	High temperature performance	9.7.15	×						
16.	Operating voltage	9.7.16		×					
17.	Charge acceptance	9.7.17		×	—				
18.	Charge stability	9.7.18		×	—				
19.	Short circuit current	9.7.19	×	—	—				
20.	Duty cycle	9.7.20	×	—	×				
21.	Life cycle	9.7.21				×			
22.	Topple test	9.7.22						×	
23.	Vibration	9.7.23						×	
24.	Acceleration	9.7.24						×	
25.	Tropical exposure	9.7.25						×	
26.	Altitude test	9.7.26						×	
27.	Fluid contamination	9.7.27	Finished materials samples to be tested						
28.	User trials	9.7.28							×
29.	Storage	9.7.29						×	

× The number of samples required for user trials will be specified in the supplementary specification of the battery.

9.2.1 *Criteria for Compliance*

All samples successfully pass all the type tests including user trials for proving conformity with the requirements of this specification. If any of the sample fail in any of the type tests including user trials, the battery shall not qualify the type approval. The inspection authority may investigate the reasons for failure and the manufacturer may resubmit fresh samples after incorporating necessary improvements for further evaluation.

9.3 Acceptance Tests

The tests specified in Table 2 shall constitute acceptance tests. The inspection authority at its discretion may also subject the sample batteries to tests listed in Table 1 including environmental tests.

Table 2 Acceptance Tests in Order of Application

(*Clause* 9.3)

Sl No.	Test Details	Clause Reference
1.	Physical examination	9.7.1
2.	Dimensions and weight	9.7.2
3.	Markings	9.7.3
4.	Polarity of plates	9.7.4
5.	Efficiency of sealing	9.7.5
6.	Di-electric test	9.7.6
7.	Nominal capacity at 1 h rate	9.7.7
8.	Un-spillability	9.7.8
10.	High rate discharge at normal temperature	9.7.12
11.	High rate discharge at low temperature	9.7.13

NOTE — The inspection authority at its discretion may also subject the sample batteries to tests listed in Table 1 including environmental tests.

9.3.1. *Sampling Plan*

The acceptance tests are intended for checking the quality of batches of batteries selected at random, and the number of batteries to be selected from the lot shall be 100 percent for conducting all tests except Sl No. 7, 10 and 11 of acceptance tests for which no defective battery is permitted. Tests of Sl No. 7, 10 and 11 of acceptance tests shall be conducted on 2 percent batteries of the lot subject to minimum 3 pieces.

9.3.2 *Criteria of Acceptance*

If any one piece fails during testing, a further sample of double the sizes as taken in the first stage shall be taken and tested. If the number of defective is zero, the lot shall be considered as conforming to the requirement of the standard otherwise the lot shall be considered as not conforming to the requirement of the standard.

NOTE — For the above sampling plan, the value of AQL comes out to be around 4 percent which means that the lot, has a high chance of acceptance test even if the lot is having 4 percent defective batteries. Therefore the user is expected to check and carry out 100 percent pre-installation check.

9.4 Routine Tests

The test specified in Table 3 shall constitute the routine tests.

Table 3 Routine Tests

Sl No.	Test Details	Clause Reference
1.	Physical examination	9.7.1
2.	Markings	9.7.3
3.	Polarity of plates	9.7.4
4.	Efficiency of sealing	9.7.5
5.	Di-electric test	9.7.6

9.6 Test Equipment

9.6.1 *Accuracy of Measuring Instrument*

The measuring equipment used for the tests shall have at least the following degree of accuracy and be regularly calibrated:

Voltmeters shall comply with IS 1248, Class index 0·5 or better.

Ammeters shall comply with IS 1248, Class Index 0·5 or better.

Time measurement shall be to a minimum accuracy of 0·5 percent. The range of the measuring instruments shall correspond to the values being measured.

9.7 Method of Tests

Method of tests to be carried out for proving conformity of the batteries with the requirements of this specification are described below.

9.7.1 *Physical Examination*

The batteries shall be physically examined for its general conditions, constructions and workmanship. The batteries shall conform to the requirements of **4** of this specification.

9.7.2 *Dimensons and Weight*

The dimensions and weight of the battery shall conform to the requirements of individual specification.

9.7.3 *Markings*

The marking on the battery shall be as per **7** of this specification.

9.7.4 *Polarity of Plates*

The polarity of plates in relation to that of the terminals and inter-cell connectors to which they are connected shall be verified electrically.

9.7.5 *Efficiency of Sealing*

The sealing of individual cells in the battery shall be tested by applying to each cell in turn nitrogen gas at a pressure corresponding to 14 kPa (140 cm water gauge). There shall be no detectable leakage during a period of 15 seconds.

9.7.6 *Di-electric Test*

9.7.6.1 A potential of 1 500 V (rms) at commercial frequency shall be applied between current carrying parts and the container for a duration of 1 minute. There shall be no chattering or breakdown of insulation during the test.

9.7.7 *Nominal Capacity at 1 h Rate*

9.7.7.1 *Initial preparation*

Prior to commencement of electrical testing the battery shall be prepared and commissioned in accordance with the manufacturer's instructions. In case the manufacturer has not provided any instructions, the battery shall be prepared for testing by charging at constant current of 0·1 C_1 amperes until the battery voltage reaches an average of 1·5 V per cell (30 V for a 20-cell battery). Then continue charging at the same current rate for 4 additional hours. When following this method, the total charging item must be at least 14 h, but not more than 16 h. During the last hour of charging and without interrupting the flow of current, remove the vent plugs and check the level of electrolyte in each cell. If necessary, correct the level by adding distilled water.

9.7.7.2 The battery shall be given a rest period of not less than 12 h and not more than 24 h.

9.7.7.3 The battery shall then be discharged at a constant current of 1 C_1 rate until the on-load voltage reaches 1·0 V times the number of cells connected in series. The duration shall be noted.

9.7.7.4 *Capacity tests*

Following the above conditioning cycle, the battery shall be re-charged by one of the methods given below or as per the manufacturers instructions:

a) 0·5 C_1 amperes for at least 2 h followed by 0·1 C_1 for 5 h; and

b) 0·1 C_1 amperes for 15 h.

9.7.7.5 The battery shall be given a rest period of not less than 12 h and more than 24 h.

9.7.7.6 The battery shall then be discharged at 1 C_1 rate until the on-load voltage reaches 1·0 V times the number of cells connected in series. The duration of discharge shall not be less than 60 minutes.

NOTES

1 If the full rated capacity is not obtained at the first discharge after the first full charge, up to three additional cycles may be formed and the full rated capacity shall be obtained on one of these cycles.

2 The temperature during charge/discharge and storage (rest) shall be preferably maintained between 27°C ± 2°C.

9.7.8 *Unspillability*

9.7.8.1 *Batteries designated as aerobatic*

The battery shall be tested in the fully charged condition with the electrolyte level adjusted to the level recommended by the manufacturer. It shall then be charged at a constant potential of 1·425 ± 0·01 V per cell for a period of 2 h previous to the test.

The charging shall be continued during the test and the battery shall be securely attached to a platform capable of being rotated about its x-horizontal axis, the battery being centralized with its major length above and parallel to the axis of rotation. The platform and battery shall be rotated ten times with a pause of 30 s after each half-revolution. The speed of rotation shall be equivalent to one revolution per 5 s. The test shall be repeated with the minor length of the battery centralized over the axis of rotation. There shall be no spillage of electrolyte from the battery and the battery shall satisfy the insulation test values as specified in **9.7.9**.

9.7.8.2 *Batteries designated as non-aerobatic*

The battery shall be tested in the fully charged condition with the electrolyte level adjusted to the level recommended by the manufacturer. It shall then be charged at a constant potential of 1·425 ± 0·01 V per cell for a period of 2 h previous to the test. The charging shall be continued during test and the battery shall be slowly rocked ten times from side to side through an angle of 60° on either side of the normal vertical position and in any direction therefrom. The time taken to move from one tilted position through the vertical to the other tilted position shall be not more than 20 s and the battery remain in each tilted position for at least 5 s. There shall be no spillage of electrolyte from the battery and the battery shall satisfy the insulation test values as specified in **9.7.9**.

9.7.9 *Insulation Resistance*

9.7.9.1 The insulation resistance measured at 250 V DC (applied for 1 minute) shall be greater than 15 K ohms between the negative terminal and container immediately after charge without cleaning.

9.7.9.2 After cleaning, the insulation resistance shall be greater than 10 m ohms then measured in accordance with **9.7.9.1**.

9.7.10 *Internal Resistance*

9.7.10.1 The battery shall be prepared and charged in accordance with the manufacturer's instructions and then stabilized at the test temperature for 16 h to 24 h. The test shall be performed at 25°C and then repeated at −10°C and −26°C.

9.7.10.2 A resistive load commencing at a value chosen to give an on-load voltage of 0·66 ± 0·05 volts per cell shall be stepped without break in five sensibly spaced increments to a value required to give an on-load voltage of 1·00 ± 0·05 volts per cell. The stepping shall be such that each load is applied for a period of 2·0 ± 0·1 s. The battery terminal voltage and current shall be measured at the end of each 2 s period.

9.7.10.3 The internal resistance of the battery shall be determined by the slope of the tangent at the 0·8 volts per cell on the plot of battery terminal voltage versus current. The value of internal resistance shall be as specified in the individual specification.

9.7.10.4 The plot of voltage versus current shall form part of the type approval test report.

9.7.11 *Charge Retention*

9.7.11.1 The battery shall be charged in accordance with **9.7.7.4** and shall stand on open-circuit for 28 days at 25 ± 2°C.

9.7.11.2 It shall then be discharged at the 1 C_1 rate. The capacity obtained shall not be less than 75 percent of that obtained during nominal capacity test given at **9.7.7**.

9.7.12 *High Rate Discharge Test at Normal Temperature*

9.7.12.1 The battery shall be charged in accordance with **9.7.7.4**.

9 7.12.2 The battery shall be given a rest period of 3 h to 5 h after charge.

9.7.12.3 Unless otherwise agreed, the battery shall then be discharged at the 7 C_1 rate at 27 ± 2°C to a battery end voltage corresponding to a mean voltage per cell of 0·76 V. The battery shall give a minimum duration of 5 minutes unless otherwise specified in the individual specification.

9.7.13 *High Rate Discharge at Low Temperature*

9.7.13.1 The battery shall be charged in accordance with **9.7.7.4**. The rest period of 3 h to 5 h shall be given after charge.

9.7.13.2 The battery shall be stored for 16 h at a temperature of minus 18 ± 2°C or till the temperature of the electrolyte reaches minus 18 ± 2°C.

9.7.13.3 Unless otherwise agreed, the battery shall then be discharged at a constant current of 25 C_1 rate for 10 seconds immediately followed by a rate of 10 C_1 for 50 seconds.

9.7.13.4 During the 10C_1 discharge the battery shall give a minimum voltage of 0·5 V per cell unless otherwise specified in the individual specification.

9.7.14 *Low Temperature Performance*

9.7.14.1 The battery shall be fully charged as per **8.7.7.4**.

9.7.14.2 The battery shall be given a rest period of 3 h to 5 h after charge.

9.7.14.3 The battery shall be stored for 16 h at a temperature of minus 40 ± 2°C or till the temperature of the electrolyte reaches −40 ± 2°C.

9.7.14.4 The battery shall then be discharged at a constant current of 1 C_1 A to an end point voltage corresponding to a mean voltage of 1·0 V per cell maintaining the ambient temperature at minus 40 ± 2°C.

9.7.14.5 The duration of discharge shall not be less than 30 minutes unless otherwise specified in the individual specification.

9.7.15 *High Temperature Performance*

9.7.15.1 The battery shall be fully charged as per **9.7.7.4**.

9.7.15.2 The battery shall be given a rest period of 3 h to 5 h after charge.

9.7.15.3 The battery shall be stored for 16 h at a temperature of 50 ± 2°C or till the temperature of the electrolyte reaches 50 ± 3°C.

9.7.15.4 The battery shall then be discharged at constant current of 1C_1 A to an end point voltage corresponding to a mean voltage of 1·0 V per cell maintaining the ambient temperature at 50 ± 2°C.

9.7.15.5 The duration obtained shall not be less than 42 minutes unless otherwise specified in the supplementary specification.

9.7.16 *Operating Voltage*

9.7.16.1 For permanent connections to do busbars of 28 ± 0·5 V, the battery shall withstand the transient voltage as shown in Fig. 1. The battery shall meet the requirements of **9.7.7.4** (capacity test) after being subjected to transient voltage test.

9.7.17 *Charge Acceptance*

9.7.17.1 After standing for not less than 16 h and not more than 24 h at an ambient temperature of 27 ± 5°C, a charged battery shall be discharged at the 1 C_1 rate to an end voltage corresponding to a mean voltage per cell of 1·00 V. The discharge time shall be recorded.

9.7.17.2 The battery shall be re-charged as per **9.7.7.4** and then discharged at the 1 C_1 rate for 75 percent of the duration obtained of the discharge as per **9.7.17.1**. After standing for

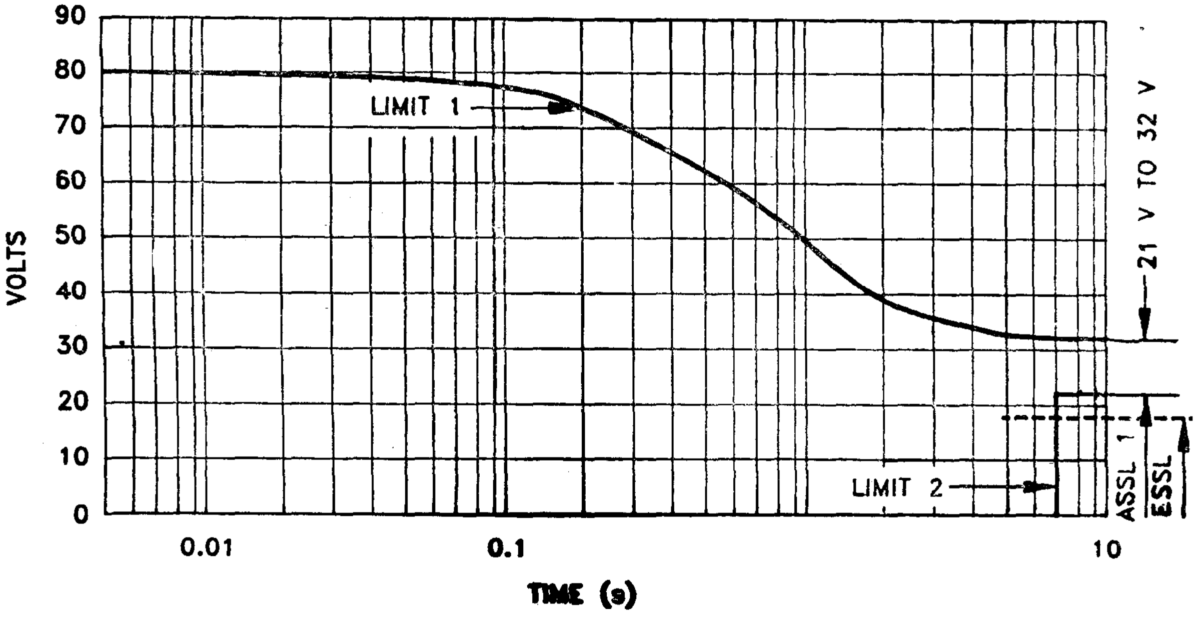

FIG. 1 ENVELOPS FOR STEP-FUNCTIONS FOR AC SURGES WHERE THE AC POWER SOURCE IS A DC GENERATOR OR A TRU SUPPLIED FROM A VARIABLE — FREQUENCY AC SYSTEM

not less than 16 h and not more than 24 h, the battery shall be charged at the recharge voltage of 28·5 V for a period of 3 h unless agreed between user and manufacturer of the battery. After 1 h stand at 27 ± 5°C, the battery shall be discharged at the 1 C_1 rate. The duration of this discharge shall not be less than 90 percent of the duration recorded for discharge as per **9.7.17.1**.

9.7.17.3 The above test procedure as per **9.7.17.2** shall be repeated except that the recharge time shall be of 20 minutes. The duration of this final discharge shall not be less than 80 percent the duration recorded for discharge as per **9.7.17.1**.

9.7.18 *Charge Stability*

9.7.18.1 *General test conditions*

The test shall be carried out in a test chamber having a cross-sectional area of not less than four times that of the battery face normal to the air flow which shall be that face containing the connector mounting.

The air flow across the working section of the chamber shall be at a speed of 600 ± 150 mm/s, measured before installation of the battery. The battery shall be approximately centred, vertically and horizontally within the chamber.

Batteries with assisted ventilation shall be so connected that air at test temperature, which may be taken from the test chamber, is extracted through the battery venting chamber at the rate of 0·040 ± 0·004 m^3/min and discharged outside the test chamber.

The battery shall be prepared and charged in accordance with **9.7.7.4**. The temperature of the battery shall be stabilized at 45 ± 2°C before commencement of the test.

9.7.18.2 The battery shall be discharged at the 7 C_1 rate for 5 minutes and immediately following the discharge, with the battery still in the chamber at 45 ± 2°C, a constant potential charge corresponding to 1·425 ± 0·01 volts per cell shall be carried out for 10 h, recording the charging current and chamber temperature every 15 min. After standing on open circuit for 16 h to 24 h at 25 ± 2°C, the battery shall be discharged at the 1 C_1 rate at 25 ± 2°C to an end voltage corresponding to a mean voltage per cell of 1·00 V. Voltage and centre cell temperature, measured on the intercell connector, shall be continuously recorded throughout the charge period. No water additions shall be made to the battery throughout the test.

9.7.18.3 *Acceptance requirement*

During the constant potential charge the charging current shall not increase from the minimum value during this period by more than the 0·2 C_1 rate over the 10 h period and the temperature of any cell shall not exceed 70°C. The duration of discharge at the 1 C_1 rate shall not be less than 48 min. At the end of test, the battery after charging shall be serviceable.

9.7.19 *Short Circuit Current*

9.7.19.1 The battery shall be prepared and charged in accordance with **9.7.7.4** and then stabilized at a temperature 27 ± 2°C.

9.7.19.2 The test circuit shall comply the appropriate mating connector and cable, with a switch and ammeter shunt suitable for the anticipated short circuit current. The total resistance of the test circuit when measured at room temperature shall be 1·5 ± 0·5 m ohm.

9.7.19.3 The test circuit shall be connected to the battery and the current measured against time for a period of 60 seconds. The terminal voltage of the battery shall be recorded throughout the test.

9.7.19.4 After the test, the battery shall be examined for damage and shall then be serviced in accordance with manufacturer's instructions and capacity tested as per **9.7.7.4**. No significant change in battery condition or performance shall result from the test.

> **WARNING** : Proper care and precautions shall be taken while carrying out the above test, due to possible fire/explosion hazard involved in this test.

9.7.20 *Duty Cycle Test*

9.7.20.1 The battery shall be prepared and charged in accordance with **9.7.7.4**. The ambient temperature of 27 ± 2°C shall be maintained during this test, unless otherwise stated in the requirement.

9.7.20.2 The fully charged battery shall stand on open circuit for a period of 14 days.

9.7.20.3 The battery shall be discharged at a constant rate of 0·5 C_1 for 10 ± 0·5 min.

9.7.20.4 The battery shall then be immediately discharged through fixed resistor for 20 seconds followed by a 1 min stand on open circuit. The battery shall again be discharged through the fixed resistor for 20 sec. The value of the fixed resistor, in ohms, shall be within ± 4 percent of 0·035 times the number of cells divided by 1C_1.

9.7.20.5 The battery shall then be charged at a constant potential of 1·425 ± 0·01 volts per cell for 1 h ± 2 min. The constant potential supply shall have a current rating greater than 8C_1.

9.7.20.6 The battery shall stand for 50 min on open circuit.

9.7.20.7 The procedure specified in **9.7.20.3** to **9.7.20.6** shall be repeated continuously for 50 cycles. The topping of the electrolyte shall be carried out after 25 cycles.

9.7.20.8 At the end of this period, the battery shall immediately, be discharged at a constant rate of 1 C_1, to an average and point voltage of 1·00 volt per cell.

9.7.20.9 The battery shall meet the requirements of this test if:

a) minimum terminal voltage during test is not less than 0·65 volts per cell;

b) its temperature does not exceed 50°C and the current decreases below 0·2 C_1 amperes during the constant potential charge; and

c) the duration of the 1 C_1 discharge is not less than 48 min.

9.7.20.10 The battery shall be given a normal service as per **4.1.11** and charged as per **9.7.7.4**, after allowing the battery to stand open circuit for 16 h to 24 h at an ambient temperature of 25 ± 2°C, the battery shall be discharge dat 1 C_1 rate at 25 ± 2°C, to a battery end voltage corresponding to a mean voltage per cell of 1·00 volts per cell.

9.7.20.11 The battery shall meet the requirements of this test if:

a) the duration of the 1 C_1 discharge is not less than 60 min;

b) it has not exhibited any sign of physical distortion;

c) the manufacturer's separator tests are satisfied;

d) the water consumption per cell during maintenance charge does not exceed the defined quantity of consumable electrolyte specified in the manufacturer's instructions for the battery;

e) the insulation resistance complies with **9.7.9**; and

f) it meets the manufacturer's requirements for a serviceable battery in all other respects.

9.7.21 *Life Cycle*

9.721.1 This test shall be carried out after satisfactory performance of the batteries in nominal capacity test at 1 h rate in accordance with **9.7.8**. The ambiet temperature during life cycle test shall be maintained at 27 ± 5°C unless otherwise stated in the clauses.

9.7.21.2 The following automatic charge/discharge cycles including the high rate discharge performance shall be carried out on the batteries:

a) charge the battery at a constant current of 0·4 C_1 A for 4 h duration. The subsequent cycles of charging on the battery shall be carried out at a constant current of 0·4 C_1 A for 3 h;

b) discharge the battery at 0·8 C_1 amperes for 1 h duration;

c) the battery shall stand an open circuit to complete 6 h duration including (a), (b) and (c);

d) the battery shall be subjected to high rate discharge performance test at 7 C_1 rate for 5 min duration, during 10th cycle and each exceeding 10th cycle; and

e) continue the above cycling for 400 cycles.

9.7.21.3 The battery shall meet the requirements of this test if:

a) the minimum terminal voltage at the end of 0·8 C_1 A discharge test is not less than 20 V;

b) There shall be no evidence of cell venting or leaking. The metal parts namely intercell connectors, terminals, nuts etc shall show no corrosion and stripping of protective coating and insulation degradation; and

c) the battery shall give a minimum duration of 54 minutes when subjected to 1C_1 A discharge test. Normal servicing of the battery shall be carried out as per **4.1.11** before subjecting the battery for 1 C_1 A discharge test.

NOTE — During life cycle test normal servicing of the battery can be carried out, in case only it is required.

9.7.22 *Topple Test*

9.7.22.1 The battery shall be placed upright on a horizontal steel plate 6 mm to 12 mm thick which has been wet floated, set and volted to a concrete block not less than 0·5 mm thick.

9.7.22.2 The battery shall then be pivoted about each edge in turn until the opposite edge of its base is raised to a height of 100 mm or until the horizontal axis of the battery makes an angle of 45° with the steel plate, whichever occurs first, and dropped freely from this position.

9.7.22.3 The battery shall not suffer damage as a result of this test.

9.7.23 *Vibration*

9.7.23.1 *Battery mounting*

The battery shall be mounted with the base of the battery in a horizontal plane irrespective of the axis of vibration. It shall be secured directly on the vibration generator table by its normal method of mounting.

9.7.23.2 *Resonance search test*

An initial resonance search test shall be carried out with a sweep rate of 0·1 octaves per minute, using the following co-sinusoidal conditions;

5 Hz to 10 Hz (2·5 mm constant amplitude)

10 Hz to 60 Hz (1·0 gn constant acceleration)
60 Hz to 85 Hz (0·075 mm constant amplitude)
85 Hz to 1 000 Hz (2·0 gn constant acceleration).

The sweep shall be carried out in each of three mutually perpendicular axes and throughout the search the frequencies at which any equipment malfunction or mechanical resonances occur shall be noted.

9.7.23.3 *Standard endurance test*

An endurance test shall then be carried out with a sweep time of less than one octave per minute, using the following conditions:

10 Hz to 60 Hz (1·0 gn constant acceleration)
60 Hz to 85 Hz (0·075 mm constant amplitude)
85 Hz to 1 000 Hz (2·0 gn constant acceleration)

The duration of the test and the direction of acceleration shall be:

3 h lateral;
3 h force and after; and
3 h vertical.

2 h in each direction shall be carried out in the frequency range 60 Hz to 1 000 Hz and 1 h in the frequency range 10 Hz to 60 Hz. Additionally, if resonance has been noted in **9.7.19.2** the battery shall be vibrated for a period of 1 h at each fundamental resonant frequency in the appropriate axis.

9.7.23.4 The battery shall be fully charged prior to the endurance vibration in all axes. During all tests, the battery shall be discharged at the 0·1 C_1 rate and the battery voltage and current shall be continuously recorded such that variation or interruption of the output may be detected. There shall be no interruption of output and no abnormal variation of voltage or current. The response time of the monitoring instrumentation shall be 0·5 m.

9.7.23.5 On completion of the testing, there shall be no damage to the battery or leakage of electrolyte from the battery.

9.7.24 *Acceleration*

9.7.24.1 A charged battery shall be secured by its normal method of mounting to a suitable fixture which in turn is securely fixed to the centrifuge. A battery designated as 'non-aerobatic' may be fitted with blocking vents during the test to avoid unnecessary spillage of electrolyte.

9.7.24.2 The acceleration conditions shall be as follows and shall be applied in each case for not less than 1 min:

a) Normal conditions

Lateral and force and aft axes	+2 gn to −2 gn
Vertical axis	4·5 gn to −2 gn

During test, the battery shall be discharged at the 0·1 C_1 rate and the battery voltage and current shall be continuously recorded. There shall be no intrerruption of output and no abnormal variation of voltage or current. On completion of testing, there shall be no apparent damage to the battery or leakage of electrolyte from the battery.

b) Crash condition:

Lateral and force and aft axes	+0 gn to −9 gn
Vertical axis	4 gn to −4·5 gn

On completion of testing the battery may exhibit damage but shall not have broken loose from its mountings nor have ignited.

9.7.25 *Tropical Exposure Test*

9.7.25.1 A fully charged battery as per **9.7.7.4** shall be subjected to cyclically varying temperatures ranging from 35 ± 1° C to 5°C, while the relative humidity is maintained at not less than 95 percent throughout the entire test.

9.7.25.2 Each cycle shall last 24 h, consisting of the attainment and maintenance of the upper temperature for 12 h and the lower temperature for not less than 5 h.

9.7.25.3 This cycle shall be repeated for 14 days (14 cycles).

9.7.25.4 The battery shall meet the following requirements after completion of this test:

a) The battery shall be visually examined and shall show no electrolyte leakage, corrosion of metal parts and stripping of protective coating and insulation degradation; and

b) The battery shall give a minimum duration of 54 min when subjected to 1 C_1 A discharge test to an end point voltage of 1·0 per cell. Normal servicing of the battery shall be carried out as per **9.1.11** before subjecting the battery for 1 C_1 A discharge test.

9.7.26 *Altitude Test*

9.7.26.1 A fully charged battery as per **9.7.7.4** shall be placed in an altitude chamber (within two hours of charging). The chamber pressure shall be reduced to a pressure equivalent to an altitude of 20 km at the rate of 5 km/min. Unless otherwise stated in the supplementary specification of the battery.

9.7.26.2 The batteries shall then be discharged at 1 C_1 A rate to an end point voltage corresponding to a mean voltage of 1·0 V per cell.

9.7.26.3 The duration of discharge obtained shall not be less than 54 min.

9.7.26.4 After completion of this test, the batteries from the chamber are examined for any spillage of electrolyte.

9.7.26.5 The battery is again placed in the chamber in discharged condition, the pressure is adjusted corresponding to 20 km at the rate of 5 km/min unless otherwise stated in the supplementary specification of the battery.

9.7.26.6 The battery is charged with constant potential of 1·425 ± 0·01 V per cell (28·5 V ± 0·2 V for a 20 cell battery). The constant potential supply shall have a current rating greater than $8\ C_1$ A. The charging of the battery is continued till the charging current becomes less than 3A.

9.7.26.7 The battery is removed from the chamber and examined for any spillage of electrolyte.

9.7.27 *Fluid Contamination*

9.7.27.1 Samples of all materials used for the external surfaces of the battery case shall be subjected to a Class A occasional contamination test in accordance with BS 3G 100 Specification for general requirements for equipment for use in aircraft Part 2 All equipment subsection 3·12: 1973 (1973) fluid contamination, issued by British Standards Institution, London.

Test fluid groups 1 to 15 shall be used, and the samples shall consist of the basic material and finish as used for the construction of the battery. Whenever possible the samples shall have a minimum surface area of 20 mm^2. The samples shall be dipped into the test fluid which is maintained at a temperature of 20 ± 5°C. The samples shall then be maintained at a temperature of 20 ± 5°C for a period of 7 days.

9.7.27.2 After 7 days, the samples shall show no significant deterioration such as softening, separation, crazing or loss of symbol legibility.

CAUTION — Some contaminants have a critical flash point temperature. Testing should always be undertaken in a suitable bomb calorimeter if that temperature is exceeded.

Some contaminants may themselves, or in combination with the sample, be toxic. Due consideration should be given to this possibility before commencing the tests.

9.7.28 User trials including flight trials on the battery shall be carried out as detailed in the supplementary specification of the battery. This shall include the following:

a) Physical check,
b) Fitment trials,
c) Ground trials, and
d) Flight test.

9.7.29 *Storage*

9.7.29.1 The battery shall be stored in discharged condition.The temperature of storage shall be between 25°C to 35°C.

9.7.29.2 The battery shall be stored for a period of two years in a packed condition to protect from human atmosphere. At the end of two years, the battery shall be prepared as per manufacturer's instructions.

9.7.29.3 The battery shall meet the requirements of the following test:

a) Physical (**9.7.1**);
b) Nominal capacity (**9.7.7**);
c) Unspillability (**9.7.8**);
d) Insulation resistance (**9.7.9**):
e) Charge retention (**9.7.11**);
f) High rate discharge (**9.7.13**); and
g) Duty cycle (**9.7.20**).

ANNEX A

(*Clause* 6.1)

DESIGN REQUIREMENTS

A-1 DESIGN REQUIREMENTS

A-1.1 Service Conditions

A-1.1.1 The battery shall be designed for operation under the following conditions of environments:

a) Application : Outdoor fitted inside the aircraft
b) Temperature range : Operation −40°C to +55°C
Storage −40°C to +70°C
c) Altitude : Sea level to 20 000 m
d) Acceleration : As per **9.7.24**
e) Vibration : As per **9.7.23**
f) Fluid contamination : As per **9.7.27**
g) Explosion containment : The battery shall be designed to contain within the casing any debris or fragmentation due to internal explosive failure.

A-1.2 The battery shall be protected such that it is not adversely effected by rain and dust storm conditions prevailing in the field areas.

A-2 The battery shall consist of number of cells connected in series as required by the individual specification and shall be assembled in a stainless steel container. The interconnection between the cells is via nickel-plated EC grade copper link bars. Inside the battery container the cells are held tightly packed by plastic wedges. Vertical movement of the cells is further restrained by plastic retainer bars attached to the battery container or by insulating material made of synthetic rubber attached to the removable cover.

A-3 The manufacturer may make his own design of the cells but at the time of approval two sets of representative components used in the manufacture of the cells should be submitted to the type approval authority for their record to guide component inspection at the time of assembly during production. Once the set of components and cell container are approved, no change in design of the cell and components shall be permitted during bulk production without the prior approval of the type approval authority.

A-4 The weight of the battery in fully charged condition shall not exceed as stated in the individual specification.

A-5 The construction and dimension of the battery shall be as per drawing indicated in the individual specification.

A-6 QUALITY ASSURANCE

A-6.1 The manufacturer shall be fully responsible for performance of all inspection requirements as specified herein and shall ensure compliance with the specified requirements by the following methods:

a) Inspection materials, components and completed batteries in course of manufacture to ensure that the specified requirements are being met and that the necessary standard of workmanship and process control is being maintained.

b) The manufacturer shall prepare a quality assurance plan to be applied to the total process of producing the specified type of battery. The quality assurance plan shall be approved by the inspection authority.

c) The manufacturer's quality control organization shall apply this quality assurance plan during production and maintain records thereof.

d) Quality plan shall also list the tests that are to be carried out on completed battery. Electrical tests shall be included where appropriate.

e) Representative battery samples shall be subjected to the specified tests.

A-7 PRE-RECEIPT INSPECTION OF STORES/CONSIGNMENT

A-7.1 The batteries shall be inspected by the consignees on receipt. Any transit damage, loss or discrepancy shall be intimated by the consignees to the contractor with intimation to inspection authority. The damage/defective items shall be rectified/replaced free of cost by the contractor at the consignee's premises. Any loss/discrepancy shall be made good by the contractor within 3 months at his own cost.

A-8 WARRANTY CLAUSE

A-8.1 The stores supplied against the specification shall be deemed to bear a warranty of the contractor against defective design, material, workmanship and performance for a period of 12 months from the date of initial commissioning of the battery by the consignees. During this period if any of the items be found defective during use, the same shall be replaced by the supplier free of cost at the consignee's place.

A-9 LITERATURE/DOCUMENTS

A-9.1 The manufacturer shall supply the following documents free of cost along with the battery:

a) *Operating and Maintenance Manual*

This should cover the following aspects:

1) General information,
2) Operating guidelines,
3) Charging,
4) Maintenance,
5) Overhaul and repair,
6) Storage and shipping,
7) Trouble-shooting, and
8) Service log sheets.

b) List of parts/spare parts.

A-10 TOOL KIT

A-10.1 The tool kit is required for overhaul and repair of batteries.

The manufacturer shall supply the tool kit alongwith consisting of vent plug spanner made of plastic material and special insulated metal spanner for removal of inter-cell connector nuts and main connector.

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The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

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